

Providing Comprehensive Education in Problem Solving in Primary and Secondary Schools

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### Abstract

This article explains the need for comprehensive education in problem solving in primary and secondary schools. The article then describes strategies for providing comprehensive education in problem solving. These strategies include embedding problem solving training in classes across the curriculum and making minor adjustments to current efforts to teach domain-specific problem solving in mathematics, science, and other classes. The article concludes with a summary of characteristics of a school that are likely to facilitate implementation of these suggested strategies.

## Providing Comprehensive Education in Problem Solving in Primary and Secondary Schools

Many current primary and secondary students will enter occupations that involve solving problems. Government officials try to solve problems that range from feeding the hungry to preventing terrorist attacks. Lawyers help solve problems such as disputes between individuals involved in an accident. Physicians help patients solve health problems that range from a cold to cancer. Teachers solve problems ranging from disruptive behaviour by a student to lack of a classroom in which to teach.

Aside from occupational uses of problem solving, day-to-day life presents many problems that people either solve or fail to solve. These problems vary from the personal (e.g., how to lose weight) to the interpersonal (e.g., how to help a depressed friend) to the practical (e.g., how to get home computer software to work).

When one adds together all occupational and other opportunities for problem solving, the importance of problem solving becomes clear. Hence, primary and secondary schools ought to teach these skills to the extent possible in the context of the many other demands on the schools.

Comprehensive training in problem solving includes effectively teaching students about major problem solving strategies (see e.g., Malouff, 2002). These include (a) strategies that help a person understand the problem, e.g., visualizing the problem, considering the problem from different perspectives, and creating a model of a relevant process or situation; (b) strategies that help a person simplify the problem, such as solving one part at a time or redefining the problem; (c) strategies that help a person determine the cause of a problem, e.g., organizing relevant information into a chart and considering multiple cause and interactions; (d) strategies involving the use of external aids that help a person identify possible solutions, e.g., applying a theory and using a tool; (e) strategies involving the use of logic, e.g., questioning assumptions and reasoning by analogy; (f) strategies involving using a possible solution as a starting point, e.g., working backward and guess-check-adjust, (g) strategies that help a person function optimally

while problem solving, e.g., thinking of a problem as a challenge and working with someone; and (h) strategies to help one solve multiple problems, e.g., applying triage and solving one problem at a time.

Primary and secondary schools make some attempts to teach problem solving in specific subjects. In mathematics, for instance, realistic story problems are in vogue, and teachers commonly show students methods of solving problems. For example, children might practice determining whether they have enough money to buy two objects they want. At higher levels of schooling, students might calculate how much paint they need to paint a house. However, the problems solving methods taught, e.g., how to add or divide, tend to be specific to the domain of mathematics and to have little value when mathematics is not helpful.

In some schools science education includes problem solving training. For instance, students might repeat some experiments done by Michael Faraday or Joseph Priestly. Science students might also be presented with problems such as the question of what is in a given chemical solution or how to make a boat that moves fast. In general, however, the problem solving methods taught in science education, e.g., random assignment to conditions and systematic observation, tend to be limited to the scientific method.

Some schools provide training in social problem solving to young students (see Meer, 1987). This training for young children provides a good basis for general problem solving in that it teaches them general problem solving strategies such as identifying the problem and the goal, developing possible solutions, evaluating each option, choosing the best option, implementing it, checking how well it works, and then returning to the problem solving process if necessary. Missing is training for older students in a broad range of more sophisticated problem solving strategies such as determining the cause of a problem as a way to finding a solution.

Schools may provide practical experience in problem solving by teaching students different topics and requiring students to complete different types of assignments over the many

years of primary and secondary schooling. Learning to read is a problem that most students solve with a high level of guidance. In learning this skill, the students may also learn strategies that are useful in solving a range of problems. These strategies may include seeking help from others, trying something (e.g., sounding out unusual letter combinations such as “ough” in every possible way) and checking to see whether it works, using inductive and deductive logic (e.g., what word would fit the prior part of the sentence), and persisting. Teachers and parents suggest some of these strategies, but almost never do they point out to children the essence of the strategy and that it can be applied to many other types of problems. So children solve the problem of reading, but only to a small extent, if at all, do they acquire the ability to use the same problem solving strategies with different types of problems.

If schools were to provide and to connect systematically all the types of problem solving training and experiences mentioned above, they would provide an adequate level of training in problem solving. Most schools, however, make no attempt to provide students with the assistance they need to learn and start applying a broad range of problem solving methods.

### Comprehensive School-Based Training in Problem Solving

#### Could Be Introduced with Little Change in the Existing Curriculum

Most schools provide bits and pieces of problem solving training, especially in mathematics and science classes. These efforts could be expanded easily through five steps:

##### *(1) Asking students in mathematics and science classes to solve real-life problems.*

Students enjoy solving real-life problems. In mathematics, these can include problems the students will face, such as calculating the price of an article offered at 30% off or determining which sun screen is cheaper per millilitre, or problems the students may face some day, such as how much fuel is needed to launch a satellite into geostationary orbit. In science, the students can develop a way to test whether males or females have better health habits or

examine the effects on plants of different types of soil. Mixing together short-term and term-long, multi-step projects gives the students the widest range of problem-solving experiences.

*(2) Asking students in mathematics and science classes to consider problems outside of maths and science where the same problem solving strategies could be applied*

Students in mathematics and science classes will learn the most about problem solving if they are asked to reflect on what problem-solving methods they used and the value of each. That will help the students conceptualise the methods. Then teachers can ask the students to consider to what problems outside of maths and science that the methods could be applied. That will help the students generalise the process of problem solving to other domains.

*(3) Extending problem solving assignments to all types of classes*

Problem-based learning is common now in the training of physicians and other health professionals (Baum & Axtell, 2005; Prince, van Eijs, Boshuizen, van der Vleuten, & Scherpbier, 2005). However, the use of problem solving to teach can extend to virtually every class offered in primary and secondary schools. For instance, when a teacher asks students to find the names of specific government officials, such as the justices of a particular appellate court, the students may learn problems solving strategies (such as searching for written information, perhaps by putting in the key words in an Internet search engine) and facts (there are women in the group; there are web sites on all sorts of things). If the teacher asks the students how they completed the task (solved the problem) and then conceptualises each different method for the whole class, the teacher is doing something akin to constructive mathematics education. Some students may have brainstormed possible sources of the information, evaluated each option, chosen the best one to try, and then evaluated how well it worked. Other students may have looked in an encyclopaedia, not thinking of other options more likely to have current information. In a matter of minutes the teacher and students can compare the advantages and disadvantages of each problem solving method used. It may be that some students hit on the idea of doing an Internet search using certain key terms. If some

students want to learn how to do an Internet search, other students or the teacher could help or guide them. It would have been faster for the teacher to tell the students the names of the Justices, but the students would have lost a valuable opportunity to learn problem-solving skills.

In physical education, students could solve problems of how to find the rules of a sport such as badminton or how to learn to play the sport. In a personal development class, students could try to solve interpersonal problems such as being teased. In a psychology or economics class, students could try to solve local or world problems in simulations.

Putting into the curriculum occasional problem solving assignments can have great benefits, especially when the teacher helps the students conceptualise and evaluate the value of the problem solving methods used.

#### *(4) Providing problem-solving opportunities relating to real school problems*

Teachers could ask students to develop a plan to solve school problems such littering or bullying or how to raise money for a charity. Even outside of classes, students could try to solve real problems. Players on a sport team might try to solve the problem of losing too many games or players getting hurt too often. The reinforcement potential of contributing to solving a real problem that affects other people is tremendous.

The potential for real problem-solving experiences in school is great. Students can learn from both failures and successes *if* (a) they receive guidance in how to identify the methods they used and where they went wrong – or right and (b) teachers and administrators keep a focus on learning the process of problem solving more than on success in solving a particular problem

#### *(5) Providing formal training in general methods of problem solving.*

School-based training in problem solving should also include some formal instruction in problem solving methods. There are dozens of methods used to solve problems (Malouff, 2002). Students can learn these methods through instruction, modelling, rehearsal, and feedback (see Rosenshine, 1999). This process is already commonly used, especially in mathematics training. The maths teacher explains a method of solving a type of problem, gives examples,

asks the students to solve problems, and gives them feedback on their performance. The same teaching approach can be used with general problem solving methods, such as clarifying the problem, challenging assumptions, identifying key elements of the problem, visualizing the problem, simplifying the problem, reasoning by analogy, and applying a theory. The broader the range of problems the students tackle, the more generalizable their problem solving skills will be.

A school could institute comprehensive problem solving training with a few hours of teacher training focused on general problem solving methods, along with discussion of how to look for opportunities for students to use good methods to solve problems. Not all teachers would have to participate in order for the training, over several years, to cover problems solving in a comprehensive way. Periodical reviews of steps taken to train students in problem solving would help keep the effort on course.

#### Which Schools May be Able to Provide Comprehensive Training in Problem Solving

Not all schools may be able to institute the changes suggested in this article. The schools most likely to successfully implement the changes are those that (a) have a principal who is a good leader and who is interested in helping students become problem solvers, (b) have teachers most of whom are open to change, and (c) have students almost all of whom are learning well and cooperating with teachers. Under these circumstances, the changes would be feasible because they involve relatively little training of teachers or curriculum change (see Levine & Levine, 1999, regarding feasibility of curriculum changes).

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